UCRL-ID-125845

Overview, Goals, and Preliminary Results of E910

Laboratory Directed Research and Development at Lawrence Livermore National Laboratory (LDRD)

Final Report, Project #95-ERD-037

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January 24, 1997

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ABSTRACT

E910 is a large acceptance proton-nucleus experiment at the BNL AGS. The experiment completed its first run in the Spring of 1996, collecting more than 20 million pA events, using Be, Cu, Au, and U targets. We present preliminary results for momentum conservation, slow proton distributions, and dN/dy for negative tracks.

1. Introduction

Experiment E910 was proposed in 1994 as a facility to study proton-nucleus and nucleus-nucleus collisions at the BNL AGS [1]. Its primary detector is the EOS TPC, with additional tracking and PID detectors positioned downstream. The experiment was assembled in the A1 line using the MPS magnet in February 1996, and collected data for the following four months of proton beam.

2. Motivation

E910 was proposed primarily to study particle production in an environment in which one can study the effects of individual hadron-nucleon collisions, yet which is also relevant to the more complex nucleus-nucleus collisions that are studied in the heavy ion program at the AGS. Furthermore, E910 is equipped to search for the H^0 dibaryon via the $\Lambda p \pi^-$ and $\Sigma^- p$ channels. Finally, E910 fills in a noticeable gap in the measurement of low p_T pion production, knowledge that is crucial to the design of a $\mu\mu$ collider.

2..1 Proton-Nucleus Physics

In E910 we wish to study the enhanced strange particle yields (for AA relative to pp and normalized to pion production) that were predicted as a signature of QGP formation and observed in AA collisions at the AGS [2]. However, strange particles were also observed to increase with target mass for pA collisions [3]. Thus, a simpler mechanism — enhanced strange particle production as a result of energy stored in multiple excitations of incident nucleons — is likely. In the relatively clean environment of a pA collision, we have the ability to study this mechanism in greater detail, through the measurement of the following quantities.

Δy — rapidity loss of incident proton [11,12,13]
ν — collisions suffered by incident proton (slow proton distribution) [8,9,10]
ν_t — total collisions with target nucleons (net charge) [5,6,7]

Studies of this kind have been performed before, but with very low statistics data sets by present standards. For example, the Fermilab Hybrid Spectrometer analyzed Λ production with a sample of only 177 Λ's including all targets and p,π^+,and K^+ projectiles [5]. For comparison, the present E910 data set represents an increase in statistics of nearly three orders of magnitude.

Furthermore, our understanding of the underlying physics behind Δy, ν, and ν_t were also established with data sets of limited statistics and coverage. With E910 we will revisit baryon stopping at AGS energies, the relation between the number of primary collisions and soft proton distribution, and the use of total net charge as a probe of rescattering.

2..2 H^0-dibaryon Search

E910 is sensitive to both the $\Lambda p \pi^-$ and $\Sigma^- p$ final states of the H^0. Its production via coalescence in 24 GeV/c p+Au collisions has been estimated to be $8 \cdot 10^{-5}$ [14]. Assuming an overall efficiency of 10% for its detection in the TPC, and scaling down by two to account for the lower beam momentum of 18 GeV/c leads to a yield of $\sim$ 18 events from the current high energy run. While this is too small a prediction to yield a null result for coalescence, the conservative nature of this estimate in [14] leaves the door open for discovery.

2..3 Low p_T Pions — $\mu\mu$ Collider

A muon collider is currently in the planning stages [4]. A critical component of this collider will involve the acceleration of low p_T pions to be focused into a beam of muons. Fig. 1 shows the most relevant measurement of this region of pion production to date superimposed upon current data from E910. The distribution of pions to be measured by E910 provides a crucial piece of information to the accelerator community. We devoted some of our beam time to running with a series of thick targets (10-100% Cu/Au) to study the effects of energy loss and multiple scattering on the pions that will lead to the muon beam.

3. Experiment

E910 sits in the MPS (A1) beamline. A schematic of the experimental layout is shown in Fig. 2.

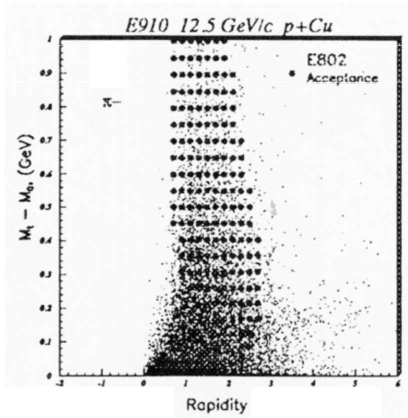

Figure 1: E910 acceptance for pions and that of next best measurement.

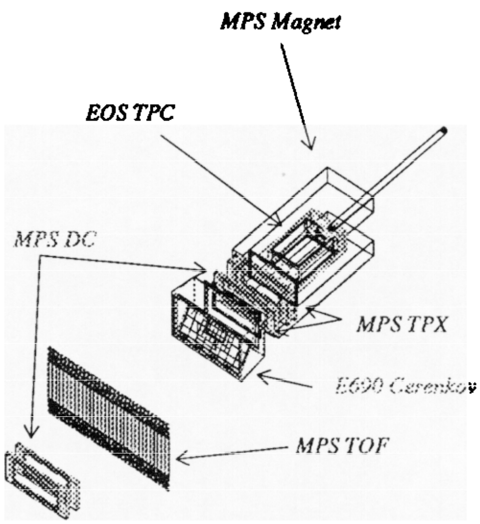

Figure 2: View of E910 Detector Layout

3..1 Detectors

The upstream beamline detectors are not shown. These include the A1–A4 beamline chambers to measure the beam momentum, and A5–A6 beamline chambers to measure the beam vector to the target. In addition, the beam is defined by two veto scintillator counters, V1 and V2, and the coincidence of two other scintillator counters, S1, which also defines the start time, and ST. For an initial set of runs, a high threshold on ST was also used to form an interaction trigger. Immediately following the target, a scintillating fiber detector (SFIB) counted charged particles above minimum ionizing, mostly slow protons. A low multiplicity threshold defined an interaction and a higher multiplicity threshold formed a "central" definition for collisions with the Au target.

As shown in Fig. 2, the following detectors sit within the MPS magnet. E910 ran with a setting of 0.5 Tesla. V2, the target, and SFIB occupy the reentrant window of the EOS TPC [15]. The TPC itself provides continuous tracking, with up to $\sim$ 128 3D space point measurements along Z, and dE/dx particle identification up to 700 MeV/c for π and 1.2 GeV/c for K,p. Three MPS drift chambers, DC1-3, sit behind the TPC along with two multi-wire proportional chambers, TPX1 and TPX2. The drift chambers each provide seven planes of projective tracking measurements. TPX1 and TPX2 each provide a single measurement in X.

Immediately after the magnet is the Çerenkov counter (CKOV), previously used in E690 at Fermilab, and E766 at BNL. The CKOV has a segmentation of 96 mirrors, and was filled with Freon 114. The MPS time of flight (TOF) wall, comprised of 32 is behind the Çerenkov. Two additional MPS drift chambers, DC4 and DC5 are behind the TOF wall, providing additional resolution for the momentum determination of stiff tracks.

Midway through the run, a Bullseye (BE) scintillator was placed in front of the TOF wall. This detector formed the primary interaction trigger for the latter part of the run.

3..2 Run Statistics

E910 collected more than 20 million events during the 1996 run. This includes approximately 10 million events for 12.5 GeV/c protons divided among Be, Cu and Au targets. Nearly 5 million 18 GeV/c p+Au were taken to study energy dependence of stopping and particle production, and also 30 thousand events for 6 GeV/c p+Be/Cu/Au collisions. We also investigated pion production for the higher energy proton beams on thick targets of Cu and Au, relevant to the eventual production of muons for a collider. For the higher energy p+Au collisions, the events are divided evenly between interaction and high multiplicity triggers.

4. Preliminary Results

4..1 Longitudinal Momentum Conservation

E910's large acceptance provides the ability to see all, or nearly all of the momentum and energy of charged final states. We will to use conservation of longitudinal momentum (and ultimately energy) to identify the charge exchange channel for the stopping analysis [16]. Fig. 3 shows the relation between total p_z in an event and the p_z of the leading particle. The

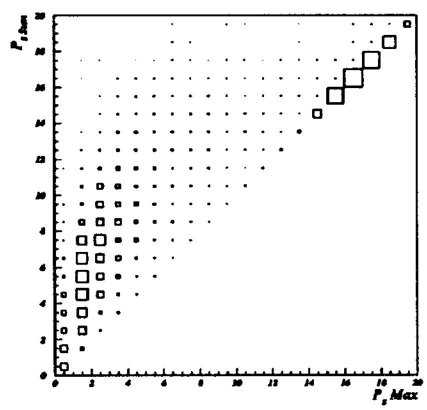

Figure 3: Total p_z for an event vs. leading particle p_z for $\sim$ 18 GeV/c p+Au minimum bias.

data in the upper right corner correspond to events for which little energy was lost by the projectile. To the left are events where the projectile was largely stopped, yet little energy was converted to neutral final states. Events which fall below a nominal cut of 8 GeV/c in total p_z are good candidates for charge exchange.

4..2 Slow Proton Distributions

Slow proton distributions are indicative of the number of interactions, ν, suffered by the projectile. The number of slow protons (p<1 GeV/c) has been deduced to be proportional to ν^2 [8], while other, more empirical derivations do not produce a strict power law dependence [9]. The limited data that exist do not distinguish between these two methods, although the general validity of measuring ν through a count of slow protons has been established.

Fig. 4 shows the difference between the positive and negative momentum distributions. Following the literature, we applied a cut of 1 GeV/c in momentum to form the distribution of residual slow positive tracks for minimum bias and high multiplicity events. Occasionally, there is a deficit of positive tracks, due to the presence of delta electrons or extremely soft positive tracks which miss the acceptance.

With the data of E910, we will reevaluate the relation between slow protons and ν, using this information to further aid in the study of particle production in pA collisions.

4..3 Pion Slopes and Yields

Finally, we measured the distributions of transverse momenta for negative tracks for four different rapidity bins, Fig. 5. Here a cut has been applied to negative tracks with a corresponding positive track at small relative opening angle ($\theta < 0.1$) to reject electron-positron pairs. For this figure, parameter P1 is yield, and P2 is the exponential slope. For both minimum bias and high multiplicity (not shown) events the fitted slopes range from 150 to

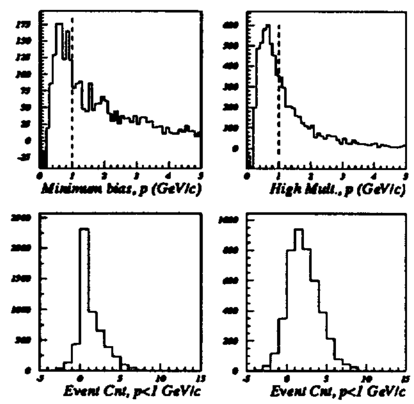

Figure 4: Slow proton (residual positive track) momentum distributions for minimum bias and high multiplicity 18 GeV/c p+Au events and slow proton counts for p<1 GeV/c cut.

180 MeV/c. Fig. 5 also shows the integrated yields for these distributions. As expected, the high multiplicity events exhibit a greater yield nearer to target rapidity, with this difference disappearing more forward in rapidity. No acceptance correction has been applied, although for these rapidity bins such corrections in E910 are small.

5. Future Analysis

E910 has made a significant start on the study of particle production in pA collisions. The data shown come from a single run and comprise less than 1% of the events recorded for 18 GeV/c p+Au alone. With more of the data, and a continued development of our analysis chain we expect to have more significant results available in the very near future.

6. Acknowledgments

This work was performed under the auspices of the United States Department of Energy at Lawrence Livermore National Laboratory under contract #W-7405-ENG-48.

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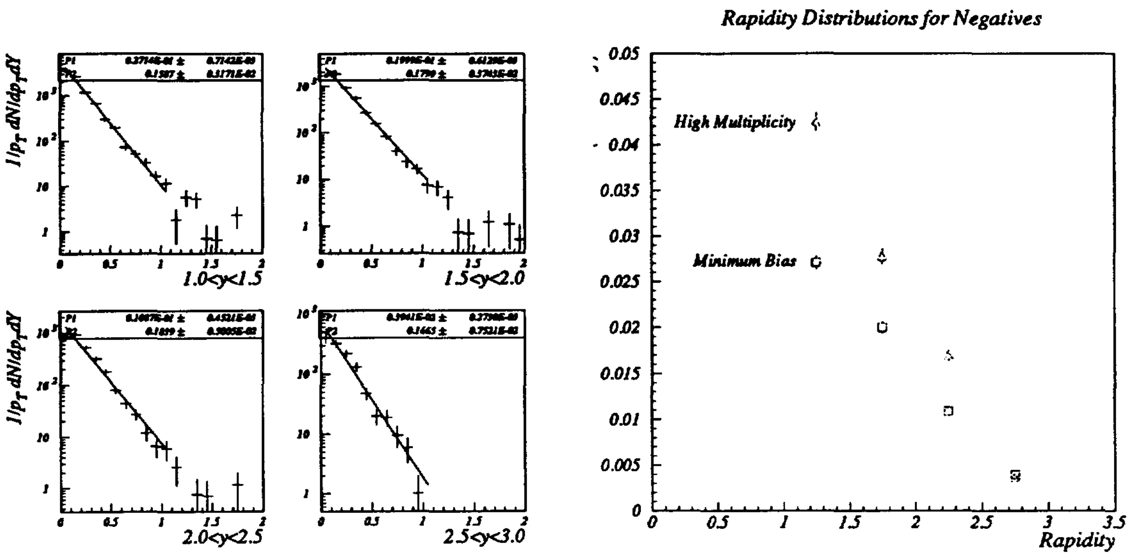

Figure 5: Transverse momentum distributions for negative tracks from minimum bias 18 GeV/c p+Au events and yields for negative tracks from minimum bias and high multiplicity events.

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